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STUDIES IN IMAGE ANALYSIS: USING ENCODED STEREO IMAGES FOR SCEN--ETC(U)  
JAN 77 J N ENGLAND, W E SNYDER DAAG29-76-G-0133

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## 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The possibility of using image coding techniques to facilitate stereoscopic depth determination for scene analysis has been investigated over the past year. A promising technique, run length coding, was applied to scene analysis. A method of encoding which helps ensure regional coherency is described. In addition, work to enable operations such as feature extraction and feature correlation in a run length coded data structure is described as is the use of these operations in determining depth information from two views of

a scene.

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STUDIES IN IMAGE ANALYSIS: USING ENCODED  
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FINAL REPORT

by

J.N. England and W.E. Snyder

January 1977

U.S. ARMY RESEARCH OFFICE

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NORTH CAROLINA STATE UNIVERSITY  
ELECTRICAL ENGINEERING DEPARTMENT

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## ABSTRACT

The possibility of using image coding techniques to facilitate stereoscopic depth determination for scene analysis has been investigated over the past year. A promising technique, run length coding, was applied to scene analysis. A method of encoding which helps ensure regional coherency is described in this paper. In addition, work to enable operations such as feature extraction and feature correlation in a run length coded data structure is described. The use of these operations in determining depth information from two views of a scene is outlined. Finally, the design of an image acquisition system to enable implementation of the depth determination method is briefly discussed.

## I. Introduction

The purpose of the research effort reported here has been to develop methods for three-dimensional scene analysis. The particular approach used involves the encoding of two images of the scene, a derivation of depth information about the scene, and finally an analysis of this three-dimensional data in terms of some primitive descriptions of scenes.

## II. Encoding of Images

There has been a great deal of research into efficient coding of images for transmission purposes [1,2,3]. Since the input of images is a key component of the scene analysis process an effort was made to examine these coding techniques for transmission to determine their usefulness. Of the methods investigated, the technique of run length coding was found to be the most promising. A method of coding was developed, as outlined in [4], which is quite amenable to hardware implementation and which results in a data storage area reduction which, at worst, is 1:1 but may yield 4:1 to 8:1 reductions with little degradation in the image quality necessary for analysis. It should be noted here that this reduction is in storage area words, not in bits as commonly used for transmission purposes and that full spatial and intensity resolution is maintained.

Basically the encoding scheme proceeds on a top to bottom, left to right basis (the usual for raster scan systems) pixel to pixel. If the horizontal gradient measure does not exceed some threshold the pixel is added to the run and assumes the



intensity of the previously encoded pixel. If the horizontal gradient measure exceeds the threshold then the previous run is terminated and a new one begun. The new run is assigned the intensity of the encoded pixel above it in the previous line if the vertical gradient measure does not exceed a given threshold, otherwise the run is assigned the intensity of the current pixel itself. The latter case is, in effect, the start of a new region of the image. This vertical check assures a two-dimensional cohesiveness to what is basically a one-dimensional encoding process.

### III. Operations in Encoded Images

A data structure for images encoded as above is reported in [4]. The structure consists of a list of run length endpoints, a list of run length intensities, and a small pointer table to increase access ease. A method of access to run lengths located at and near a particular Cartesian coordinate is shown. The use of this method enables arithmetic or logical operations to be performed within a region of the image. It should be pointed out, however, that while this scheme can be used for operations on regularly shaped regions, its most natural manipulation leads to irregularly shaped areas. This can lead to some conceptual difficulty in the use of such a data structure.

Region growing and feature extraction algorithms have been developed to aid in using this data structure. These include a region growing technique to identify evenly shaded regions of the image, a feature extraction algorithm which

indicates locations within the image where local structure suggests a corner-like arrangement, a measure of similarity between two such extracted features for use in matching and comparison operations, and finally, a procedure to check for and trace an edge extending from one of these features to another.

#### IV. Derivation of Depth Information

In [5] a review of previously tried methods of depth determination using both single and multiple views is presented. A relatively straightforward approach to depth determination for the case of planar polygonal objects is outlined. This approach uses the encoded data structure described above along with the operations described in [4].

A target feature is extracted from one image and then compared to several candidate features extracted from the second. Next, a feature located along an edge from the previous feature is extracted and compared to candidates. The existence of an edge between the new candidate and the previously selected match is used to determine the confidence of match and helps prevent false matching. This process is extended to define polygons which are then merged through the use of the derived depth. Finally, the polygon description in three space is used to separate objects from each other and from the background.

#### V. Implementation

A flexible image acquisition and display system [6] was designed and has been partially constructed. It allows the



input of a section of an image from either of two television cameras and a simultaneous output to a display. High speed block transfers to and from host computer memory are used. The host computer has control over the acquired section size (currently limited to 4096 pixels), resolution, format and position within the television image frame. All transfers to and from the buffer memory system can take place at 100 nsec/byte transfer rates. In addition, a run-length encoder-controller has been designed so that the buffer memory may be used for this purpose.

Since the image input facility has not been completed as yet, software was written to evaluate the performance of different run length coding techniques on images stored on magnetic tape. The color display capabilities of the Signal Processing Laboratory were quite useful in the interactive design and evaluation process.

## VI. Publications

To date, the description of work performed and ideas and methods developed appears in several Signal Processing Laboratory Reports [4,5,6,7]. An expanded version of the depth determination discussion in [4] is under preparation for submission for journal publication in the future. The results of actual implementation of these ideas will be included in that publication. A discussion of these results will be submitted for presentation at appropriate conferences in the future.



## VII. Best Laid Plans...

It is not possible in advance to be certain of the results or even of the difficulties to be encountered in investigation of approaches to research problems. Several problem areas which were tackled during the course of this research failed to yield encouraging results.

It was initially hoped that some method of using the Walsh-Hadamard transform as an aid to cross-correlation of image subareas could be found. It was hoped that the computational advantages of this transform over the demonstrably useful Fourier transform could be put to use. The work of Parkyn [8,9] has shown that it is not possible to correlate unequal sized areas using the Walsh transform and that the software overhead required discourages its use otherwise. This result put an end to hopes for speeding computation and halted efforts to develop a method for transforming run length coded data.

An effort to develop a technique similar to the Fast Fourier Transform but specifically applicable to run length coded data has been put off to the future. Perhaps time will allow a re-opening of this investigation later.

It was somewhat disappointing that progress could not proceed at a greater rate on implementation of a working system for stereoscopic depth determination. Hardware construction and software development has been slowed down by the increasing usage and decreasing reliability of the computer facilities within the Signal Processing Laboratory. The facilities allow highly interactive development work and great

freedom for modifications but the major CPU, an Adage AGT-30, is primarily a discrete device system of the mid-sixties and, unfortunately, is requiring more and more maintenance.

Finally, it was somewhat frustrating to confront the reality of serial computation in a three-dimensional domain. Future advances in associative, array-oriented computer architectures will certainly be welcomed by those involved in scene and image analysis. Perhaps then the problem of performing a multi-dimensional operation will not seem so time-consuming and so awkward.

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